A GIS ASSESSMENT OF DEFORESTATION IN THE COTO BRUS VALLEY OF COSTA RICA

By

JENNY JUAREZ

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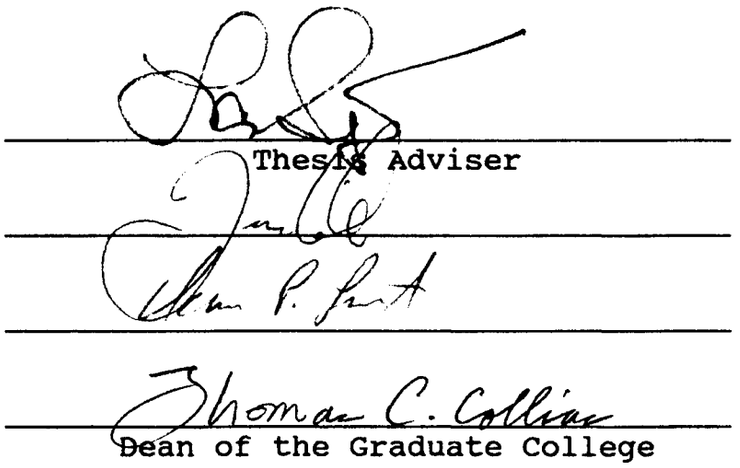

Thesis Adviser

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

During the many thousands of years before the Columbian era, Costa Rica was occupied by Amerindians, descended from Asian migrants (Hall, 1985). These people formed an American culture realm with no regular contacts with other continents, creating a niche in the tropical forest ecosystem. Once adapted to this environment, the migrants survived by hunting, fishing, gathering, and primitive cultivation. According to Hall (1985), the Indian way of living allowed them to exploit the natural environment and, at the same time, conserve the potential resources. However, Butzer (1990) states that the belief that Indians had entirely ecologically sound production systems is simplistic. According to him, the environmental impacts were greater than earlier believed. There is no proof of whether Indians cultivated once every 20 years or the land was permanently kept open and planted every other year.

When the Spanish first arrived, 98 percent of the country was forested (Brandon and Umaña, 1992). For these European settlers, the tropics represented a hostile world of which they had little prior knowledge. Europeans incorporated Costa Rica into the colonial European system with alien patterns of land use, disrupting the indigenous

way of life. Permanent forest clearings became dominant in the modern cultural landscape, taking around 450 years in the oldest areas of colonial activities, and less than 100 years in many peripheral regions. Today in Costa Rica, approximately 148,000 acres are cleared each year to open up new terrain for agriculture and livestock (Brandon and Umaña, 1992)(Appendix 1). The physical and ecological environments, and the native cultures have been transformed. According to Hall, some remnants of these cultures still survive precariously in small areas of the country as "modified indigenous ecosystems" (1985).

The Problem

The indigenous population in Costa Rica is very small in proportion to other countries in Central America, such as Guatemala and Panama. The culture and blood purity of these groups are being diminished by the non-Indian cultures, and Indians are losing identity (Bozzoli, 1984). Most indigenous groups have always lived within the forest in Costa Rica (Vargas, 1985). Contact with Europeans has pushed many of the indigenous groups deeper into the forest, creating two important concerns, one ecological and the other social. It is common knowledge that in Costa Rica original tropical landscapes have been transformed to savannas. As a consequence, dry seasons are becoming dryer. During the rainy seasons, large amounts of water cannot be stopped; erosion on the savannas has been accelerating the infertility process in the soil, and has produced

catastrophic floods in lowland areas (Hall, 1985). In the meantime, Indians have been losing land, which points up a sad reality: there is less land available for farming (CONAI, 1988). The jungle is disappearing and most Indians are resistant in adapting to a new life style.

Purpose of this Study

Keeping track of these indigenous ecosystems and of the importance of the continuing deforestation in many regions of Costa Rica have encouraged this particular project. The goal of this research is to study the interaction among the Indian people, agricultural patterns, and deforestation rates in a coffee-plantation area in southern Costa Rica. The area is located in the Coto Brus Valley, and the indigenous group present in this area is the Guaymí group. This area was selected after observation of increasing amounts of deforestation in the pacific *estribaciones* (ridges) of the southern Talamanca Cordillera.

General Objective

The main purpose of this research is to evaluate the evolution of the Coto Brus Valley as a niche for indigenous groups and tropical ecosystems, and as an active agriculture region.

Specific Objectives

a) To assess the deforestation rates in the Coto Brus Valley for a 32-year time period.

b) To identify the change in agricultural patterns practiced by the Guaymís and assess their cultural transition.

c) To assess the agricultural patterns of non-Indians and their contribution to the regional deforestation.

Significance and Limitations

In the public sector of Costa Rica, acquisition of precise information is difficult. Census information and cartographic materials ten years old are generally the most recent available. Updated information is usually gathered by private entities or international organizations for which access is more restricted. Several maps based on 1992 and 1993 sources have been derived from this study. In addition to this new information, the study is focused in a rural area with minor economic importance in Costa Rica. This fact opens the path for new topics for future research in the same southern region of Costa Rica, such as agriculture and urban planning, and natural resources management.

A study of deforestation rates in this area is useful for Costa Rican government agencies such as the *Departamento Forestal* (Forestry Department), and the *Ministerio de Agricultura y Ganadería* (Agriculture and Livestock Ministry). The study can be used as a tool in evaluating programs that consider agricultural and deforestation matters as important factors in decision-making. The *Comisión Nacional para Asuntos Indígenas* (CONAI) (National Bureau for Indian Affairs) is an institution interested in

the current boundaries of the Indian reservation, the social situation of the indigenous people, and the respective legal issues. Some other organizations interested in conservation are formed in the private sector. An example is the *Organización para Estudios Tropicales* (Organization for Tropical Studies), which currently manages the Wilson Botanical Garden in San Vito, and which is also starting a conservation project for an extended forested area, both of which are located within the study area of this research.

One of the limitations of this study is the lack of updated maps of the study area to compare land-use and vegetation coverage. Also, aerial photographs for other years between 1960 and 1992, were not available. This fact limited the size of the study area, and it also limited the calculation of deforestation rates for shorter time periods. Another important limitation was the difficulty encountered when traveling to Costa Rica to do field research. Although the author is from Costa Rica, a guide was necessary to travel to the Indian villages; where sometimes, transportation and guides are not available.

CHAPTER II

LITERATURE REVIEW

Costa Rica has a total area of 52,000 km², a population of three million people, and a per capita Gross National Product of $2,300 (Appendix 2). Costa Rica is well-known internationally for its wildlife preservation efforts, based on a system of reserves. The country has designated 26.9 percent of the national territory for wildlife reservations, including reservations for indigenous people (Fundación Neotrópica, 1988). These areas protect species in a significant proportion to the biological resources and the landscape diversity, which are also the main tourist attractions.

The protected areas system is expanding, encompassing seven management categories. The level of protection and the current management depend on the management category. There are other protected areas supported by private organizations whose main objectives are aimed at conservation, research, and tourism (Fundación Neotrópica, 1988) (Appendix 3).

Indigenous Reserves Subsystem

The main goal of reserves management is to protect the ecosystems and the way of life of the native groups. This

includes groups who occupy areas with a very low population density, and who practice traditional activities in harmony with the ecology of the area. Also, part of the goal is to allow and encourage these indigenous groups to continue their lifestyles without utilization of incompatible foreign modern technologies (Fundación Neotrópica, 1988).

The indigenous reserves subsystem is formed by 23 management units, with an area of approximately 325,470 hectares, encompassing 6.3 percent of the national territory. Despite the previously described main objective for the management of Indian groups, there is neither any kind of management nor protection, not even specific projects for indigenous reserves. The entity responsible for Indian affairs is CONAI (Fundación Neotrópica, 1988).

In Costa Rica, eight Indian groups have been settled in 21 reservations: Cabécar, Bribri, Brunca or Boruca, Térraba, Guaymí, Huetar, Guatuso or Maleku, and Chorotega. Other groups are the Misquitos, the Sumos, and the Ramas from Nicaragua, and the Teribes from Panama (Appendix 4).

The Guaymí Group

The Guaymís are located in southern Costa Rica, close to the border with Panama, in the Puntarenas Province in the *cantones* (similar to counties) of Coto Brus, Corredores, Golfito, and Osa. The Guaymí population is distributed in four reserves: Coto Brus, Abrojo Montezuma, Conteburica, and Guaymí de Osa (CONAI, 1988).

This group is characterized by a continual migratory movement from three provinces in Panama to Costa Rica: Bocas del Toro, Veraguas, and Chiriquí. The migration has become more stabilized since the creation of indigenous reserves for the tribe (CONAI, 1988).

Coto Brus Reservation

This study focuses on the Coto Brus reservation, created under a constitutional law in 1977 which set aside 7,500 hectares for its area. Statistics for 1987 showed a population of 544 Guaymís.

General Characteristics

a. Traditional clothing. The physical appearance of the Guaymís has not changed much, nor has their ancestral customs, such as costume. Almost every woman wears the typical colorful dress, with no shoes. Men's clothing has been standarized today to a white t-shirt, dark pants, and rubber boots.

b. Language. These people speak the Guaymí language. Few speak some Spanish. Education in schools is supposed to be bilingual, but, contrary to what could be expected, children do not speak Spanish; some understand it, but within the villages they are encouraged to speak Guaymí. Young boys usually learn more Spanish when they have to leave the village to work for Ladino (non-Indian) farmers.

c. Housing. Guaymís build their *ranchos* (primitive houses with one or two rooms) at ground level, with stick

walls, and roofs made from palm leaves (CONAI, 1988). With a characteristic rectangular pattern, *ranchos* are built to be far away from their closest neighbors, about 500 meters. Sometimes, families build an extra *rancho* in higher places to avoid flooding during the rainy season. Stoves are assembled with three or six stones over a table; wood is put in the center of the stones to become a small fireplace on which big pots are set. Other fireplaces are built outside the *ranchos* with stones on the ground with three logs in the middle. Cooking is done with common domestic utensils such as pots, *jarros* (rudimentary cups), and *comales* (curved pots to prepare tortillas). Food is kept hanging in bags made by the Indians. The main food in their diet is rice, which is always served in large amounts during meals. Eating is done either with spoons or with the hands (CONAI, 1988).

d. Handcrafts. Handcrafts are characterized by good quality and colorful appearance. Articles are made with natural fiber and with vegetable inks and dyes. Some examples are *chácaras* or handbags, hats, and beautiful dresses with geometric patterns. Part of their handcraft includes the bow and arrow and other intruments used for hunting and fishing.

e. Religion and traditions. Guaymís worship their own god who they call *Nubu*. There are also a general god and a evil god, the latter represented by very evil and harmful spirits (CONAI, 1988). They also practice *Mamachi* religion, which began after a Catholic virgin appeared to an Indian woman who represents the doctrine's leadership. Besides

their own beliefs, Guaymís also practice other foreign religions (Catholism, Protestantism, Bahai, etc), as a consequence of the acculturation from the Ladino influence (CONAI, 1988). However, they still maintain their own philosophy about birth, death, puberty, and matrimony. As traditions, Guaymís celebrate dances and big *fiestas* once every year or on special occasions. A particular village in the Coto Brus Valley has *chichadas* (men and women gather to drink *chicha* or maize liquor) on Saturdays almost every month. The largest and best activity is the *balsería* which can have many meanings: friendship, rivalry, or competition. In this activity they drink *chicha* and cook different dishes. The game is performed with sticks made from balsa wood played as singles or in groups, trying to hit the opponent in the ankle. Competitors stand one in front of the other, dressed up with costumes, feathers on their heads, and some makeup on their faces (CONAI, 1988).

f. Land ownership. Updated information collected by the CONAI in 1992 about the Coto Brus Reservation (7,500 ha.) reveals that 6,675 ha. of the reservation were under Indian ownership, equal to 89 percent. Land owned by Ladinos totaled 825 ha., 11 percent of the reservation (Appendix 5). According to the CONAI's statistics, the forest coverage in the reservation was about 5,250 ha., or 70 percent of the area.

g. Cultivation. Indigenous agricultural practices have peculiar characteristics that provide the possibility of keeping the general structure of the ecosystem in its

original state (Vargas, 1988). As other indigenous groups in the tropical forests of Costa Rica do, Guaymís cultivate based on climatic seasons: dry and rainy. Cultivation is done inside the forest keeping as much vegetation coverage as possible to ensure moisture to the soil, and shade to the crops (Vargas, 1988). Once the terrain's fertility is exausted, the Indians move to other parcels in the forest, keeping a rotating cultivation among the parcels. Usually, Indians allow the exhausted soil to regenerate for 10 or 15 years, depending on the extension of forest to which Indian *campesinos* have access.

In general, Guaymís cultivate cocoa, beans, rice, *palmito* (the stalk of a plant similar to plantain), plantains, tubers, *pejibaye* (seed of a thorned palm), green beans, wild green beans, and fruits. Cultivation is combined with raising domestic animals such as pigs and fowl. Guaymís also practice hunting and fishing within the reservation.

Settlement in the Coto Brus Valley

The Guaymís are related to the Turas, from the province of Bocas del Toro in Panama (Alphonse, 1968). The Turas came from the North following the Caribbean coast from Mexico looking for fish and turtles that were abundant in that region of Panama. The Turas are related linguistically to the Aztec people of Mexico; they were probably a servant class tribe to the empire. Based on the way the Guaymí venerate the Aztecs, it is believed that the Guaymís are

descendants from the Turas who probably escaped from slavery down the Caribbean coast. The descendents of the Turas, or Guaymís in Bocas del Toro were invaded by the *Misquito*, or Miskito Indians from near Bluefields, Nicaragua (Alphonse, 1968). The Guaymís escaped to the safety of high mountains, and settled part of the Cordillera in Chiriquí Province, Panama. The Guaymí inmigration to Costa Rica was probably due to some destruction of their forest environment in Chiriquí (Laurenchich, 1974). Other reasons for their immigration included non-Indian pressure and rivalry among different *caciques* (name given to Indian chiefs). Their exodus to Costa Rica took place between 1950 and 1951, following the same ancient roads used by their ancestors. Currently, Guaymís mantain a continual movement between Panama and Costa Rica (CONAI, 1988). The Talamanca range in Costa Rica and Panama forms a unique geographic region for their tribe.

From Coto Brus, many Indians go to Panama every year to join celebrations and *fiestas* given by their counterparts among the Panamanian Guaymís. The places where Guaymís live in Chiriquí are located about 150 and 200 km from Coto Brus (Laurenchich, 1974). Their villages in Coto Brus are Villa Palacios, Caño Bravo, Brusmalís, Desamparados, Limoncito, and Quebrada Pita (Figure 1).

Coto Brus Valley

This valley is located in southern Costa Rica, formed as a depression between the Talamanca Cordillera and a

coastal ridge, continuing further into Panamanian territoty (Appendix 6).

Characteristics of the Environment

a. Climate. Costa Rica is located entirely within the tropics, however, there is a wide range in seasonal conditions. This is attributed to the modification of the basic climatic patterns by elevation, slope, and aspect. The Coto Brus Valley and its surrounding mountains are characterized by having a complex succession of microclimates that vary over extremely short distances. As

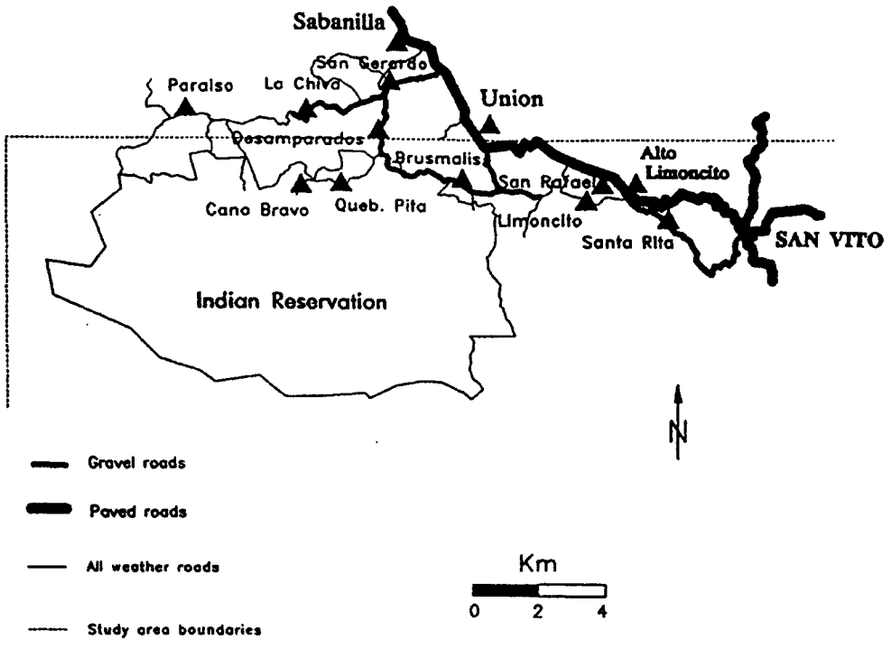

Figure 1. Indian Villages, Coto Brus Valley
Source: Topographic sheets, Instituto Geográfico de Costa Rica

the elevation increases, temperature decreases to produce cool, montane climates contrasting with the hotter temperatures in the Coto Valley, and Golfito (seven meters above sea level).

b. Precipitation. In Costa Rica there are two basic types of rainfall. *Aguaceros* are formed by the convection and the development of cumulonimbus clouds along convergence fronts (Hall, 1985, p. 19). This process results in torrential downpours which are usually localized accompanied by thunder and lightning, affecting areas of a few square kilometers, and leaving the surrounding regions untouched and dry. *Temporales* are formed by continuous rains associated with easterly waves or cyclonic disturbances (Hall, 1985, p. 19). Both types are present in the Coto Brus area, in the rest of the Talamanca mountains, and in the Pacific valleys. In the Coto Brus Valley it rains the entire year. The annual precipitation of the study area is divided into two zones: the northern zone has an annual average precipitation of 4,000 mm, and the southern part

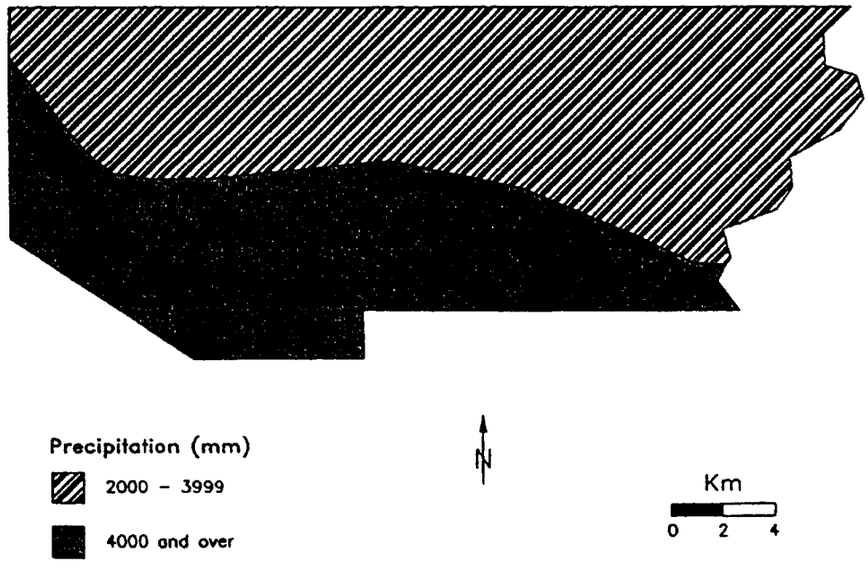

Figure 2. Annual Average Precipitacion, Coto Brus Valley
Source: Hall, 1985.

receives an average of 6,000 mm per year (Hall, 1985, p. 17) (Figure 2).

c. Temperature. In the intermontane depressions and on the lower mountain slopes in the Coto Brus Valley, mean annual temperatures range from 12° to 24°C. As in the rest of the country, seasonal variations in temperature are minimal, averaging 2° to 3°C, a pattern that is not modified by altitude as is characteristic of the tropics (Hall, 1985, p. 21) (Figure 3).

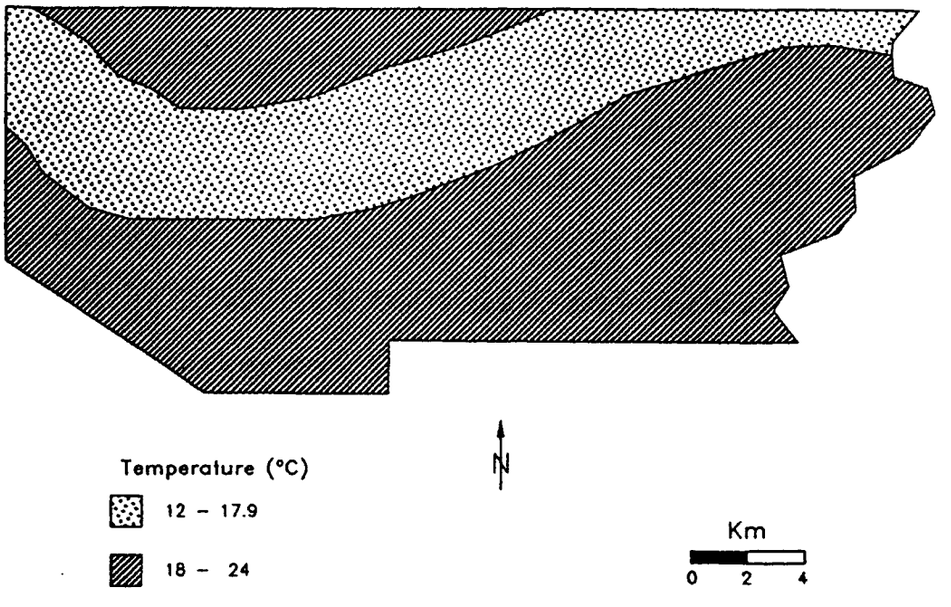

Figure 3. Annual Average Temperatures, Coto Brus Valley
Source: Hall, 1985.

d. Vegetation. Forest is the natural vegetation in the Coto Brus Valley, however, most of the landscape has been changed to savannas by shifting cultivation. The general characteristics of vegetation according to heat,

precipitation, and moisture are summarized in the description of life zones found in Coto Brus.

e. Life Zones. Costa Rica lies entirely within a tropical latitudinal zone, therefore, its life zones are classified first by elevation. Costa Rica has five elevational zones: tropical, premontane, lower montane, montane, and subalpine zones. Each of these zones is subdivided into four humidity provinces: dry, moist, wet, and rain (Holdridge, 1967).

Inside the boundaries of the study area in Coto Brus, six life zones can be identified: premontane moist forest, premontane wet forest, premontane rain forest, lower montane moist forest, lower montane wet forest, and lower montane rain forest. The premontane *moist* forest has a semideciduous upper story, 20 to 25 meters high, containing trees with stout trunks, heavy, widespreading branches, and broad, flat crowns. Its understory is composed mainly of evergreen trees and shrubs. The premontane *wet* and *rain* forests comprise an upper story of tall evergreens and understories containing a wide range of palms. The premontane forests are often denser than the tropical ones because many hillsides receive greater precipitation than adjacents lowlands, however, the number of tree species is reduced to about fifty (Hall, 1985, p. 28).

The lower montane zone is located between 1,500 and 2,500 meters above sea level. The *moist* and *wet* provinces in the lower montane zone are found only in the most sheltered slopes of the Coto Brus Valley, therefore, there

is not too much lower montane zone left in this valley. Only the areas enveloped in drizzle, cloud, and fog are still preserved. In these areas the low temperatures reduce the height of the trees with only 25 to 30 species. The understory is characterized with broad-leaved evergreen shrubs; the entire forest carries a heavy load of epiphytes (Hall, 1985, p. 29) (Figure 4).

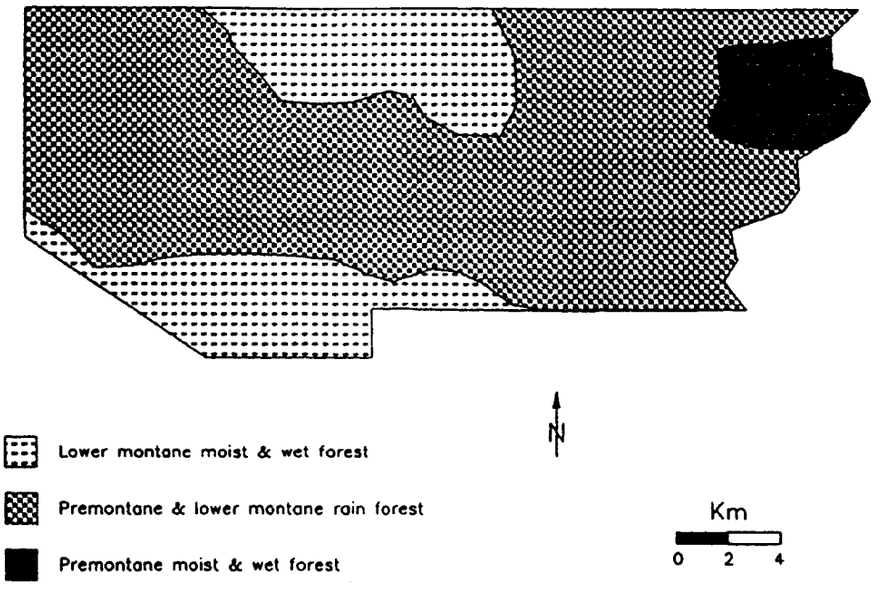

Figure 4. Life Zones, Coto Brus Valley
Source: Hall, 1985

Migratory Movement and Colonization

In the decade from 1950 to 1960 there were two types of small and independent *campesinos* (peasants) in Costa Rica: one with a European influence expanding his agriculture toward the periphery of the central area of Costa Rica. The other is the dispersed *campesino*, oriented toward coastal

and bordering zones of the country, characterized as Indian or mestizo (Laurenchich, 1984).

From the central area of the country to the south, *campesinos* moved to small towns (Acosta, Dota, Tarrazú, Tarbaca, and Puriscal) surrounding the peripheral area of the Valle Central. By the last century, the soils in these terrains were eroded by torrential rains due to the lack of vegetation. *Campesinos* could not affort to keep the soil in as good condition as commercial agriculture does. Many *campesinos* looked again for more land to settle on.

The Pérez Zeledón region, or Valle del General, located in the southern zone of the country, experienced a series of immigrations starting in 1936. With the opening of the Panamerican Highway, large numbers of people migrated to this area. By 1949, the area was overpopulated; people from all over the country found unoccupied land buying it at very low prices. All the parcels had at least a primary forest or an old secondary forest. These *campesinos* had plenty of land to slash and burn for some years. Migrants moved toward the Coto Brus Valley. *Campesinos* came from Puriscal, Parrita, and Pérez Zeledón, mainly, to join the already established Italian colony in the Coto Brus Valley (Laurenchich, 1984).

San Vito de Java: By 1952 and 1955, through an agreement between the Costa Rican goverment and an Italian immigration company, around 100 Italian families were located in the middle of the forest in southern Costa Rica (Bozzoli, 1974). These farmer families founded the town and

named it San Vito, because of its similarity with another small village in Italy.

The Italians planted coffee, which was the only feasible commercial product in that region, and with which immigrants were quite unfamiliar (Hall, 1985). Because of communication and transportation difficulties, San Vito was relegated to become an isolated area. The Panamerican Highway was constructed to the south of San Vito (Figure 5).

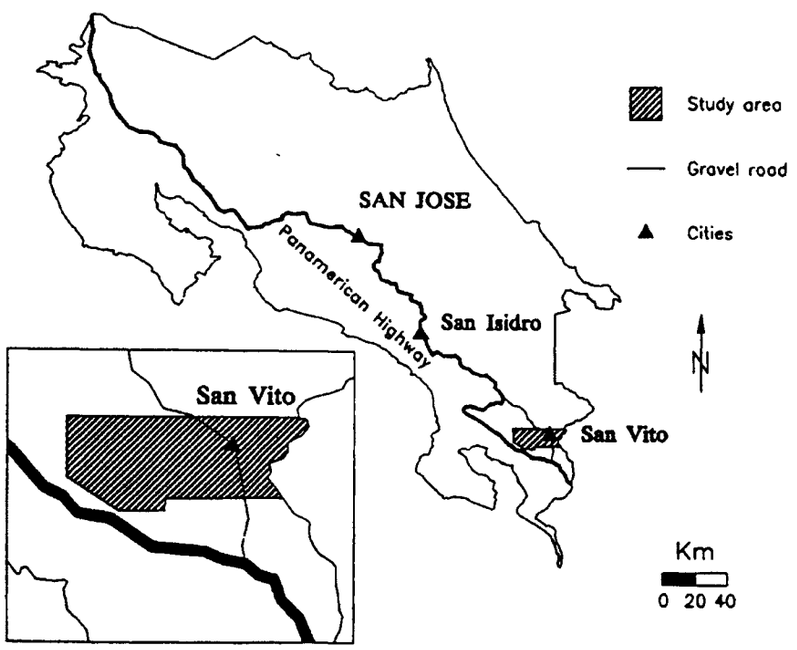

Figure 5. Costa Rica, San Vito, Coto Brus
Source: Instituto Costarricense de Turismo, 1990

This area is characterized by very steep slopes and extremely rocky terrain (calcareous rocks). The road connecting the Italian colony was not good enough to allow easy and quick transportation of products down to the port of Golfito. A tense relationship between colonists and the

immigration company, plus a severe economic situation in the region, caused the exodus of the families. Most of the families returned to Italy. The ones left had to wait for a long time until they could gather enough money to return to their country, and many of them did so in total bankruptcy. These families were replaced by Costa Rican colonists, who extended the settled area far beyond the 10,000 has. initially set aside for the colony (Hall, 1985, p. 120).

Farming System

The land use category for Coto Brus identifies crops as being predominant over pasture (Hall, 1985, p. 141). However, there is more variation in land use and export commodities are combined with food crops. Pierre Stouse did a pioneer classification of farming systems in Costa Rica in 1971. The Coto Brus Valley was classified in the category of commercial farms of the central valleys, characterized by intensive land use, dense rural population, subdivision of land into small holdings, and the predominance of cash crops. Products include coffee, sugar, rice, maize, beans, milk, fruit, and vegetables.

The Agricultural Frontier

For 20 years, Costa Rica has been experiencing a social and economical phenomenon peculiar to Latin American countries. As described by Bozzoli (1974), Coto Brus and other rural agricultural regions became the destinations for massive immigrations in the 50's and 60's. Political

boundaries of the country limited the migrational movement to border towns, which Bozzoli calls the agricultural frontier. After years of deforestation and cultivation, the exausted soils were abandoned little by little. The excess of population in zones where the land was entirely sold, or soils were exhausted, could not continue the activities practiced by their ancestors. This population was then converted to *peones* (farm hands), and employees of nearby urban centers. As in the case of the Coto Brus Valley, the once so prosperous agricultural frontier was closed to immigration. Land was dedicated to large projects, such as hydroelectric dams, export products, and livestock expansion programs (Bozzoli, 1974). The traditional independent *campesino* became rural and urban squatters, *jornaleros* (part-time *peones*), and urban employees. Outmigration started; people were leaving rural areas to go to urbanized centers. As a consequence, the production of basic grains was dramatically reduced. It is common knowledge in Costa Rica that the government began many projects at this time to encourage unemployed population and former *campesinos* to go back to agriculture. These projects were not very successful. The urbanized *campesino* started populating poor residential areas surrounding large urban centers in the Meseta Central. The once few and small marginal neighborhoods of San José became overpopulated. The lack of jobs and social decline increased deliquency on the streets.

Today, this social and economic phenomenon persists. Population is increasing at a high rate in Costa Rica, and

the government struggles to find better solutions to urban planning and general economic relief.

CHAPTER III

METHODOLOGY

Research Methodology

The purpose of this research is to record change over time in the Coto Brus Valley. Four topographic sheets were used to determine the boundaries of the study area in southern Costa Rica. Aerial photographs covering this area were obtained to compare the rates of deforestation in the Coto Brus Valley over a period of 32 years. The photographs were digitized to create two maps showing the boundaries of deforestation for each year. Statistics were obtained from both maps to determine the difference in forest boundaries in order to calculate the rate of deforestation. The output of this process was a map which was used to compare a land-use map and aerial photographs in order to analyze agricultural patterns from both Indians and Ladino *campesinos*.

Research Instruments

Available Maps

The study area in the Coto Brus Valley is covered by four topographic sheets. These sheets were prepared by the *Instituto Geográfico de Costa Rica* (Geographic Institute of

Costa Rica) in UTM projection based on 1960 aerial photographs. The area was delineated according to coverage as determined by the sets of aerial photographs which were drawn on the topographic sheets. These sheets provided information about contour lines, roads, airports, rivers and streams, political boundaries, cities, towns, vegetation cover, and national parks boundaries.

The land-use map of the study area was based on 1985 field work done by the *Dirección General de Estadísticas y Censos* of Costa Rica (General Administration for Statistics and Census). This map shows the boundaries for different types of crops in the study area. A manual attached to the map explains the categories that are represented with numbers and letters on the map.

Aerial Photographs

Aerial photographs were selected according to the coverage area and years available. For Costa Rica, aerial photographs could be found for the entire country and, in some cases, for different years for the same area. Another advantage provided by the aerial photos is their scale of 1:60,000. This ground resolution is much better than what is provided by a Thematic Mapper image (30 x 30 meters ground resolution) in which the canopy in the image is not clear for small areas of study.

Four different flight lines of aerial photographs were obtained to be compared for a period of 32 years. The photographs were obtained from the *Instituto Geográfico de*

Costa Rica. Three different flight lines taken in 1956 and 1960 were compared to a flight line of six photographs from February 16, 1992. The 1992 photos run from east to west. The other three sets of photographs run from southeast to northwest. The first flight line of five photographs was taken on March 2, 1956 and covers the upper part of the study area; the other two flight lines of thirteen photos were taken on March 1, 1960.

Hardware and Software

The hardware included PC computers, a tablet digitizer, and an Ink Jet printer. The software used was ATLAS*DRAW to digitize the aerial photographs; and ATLAS*GRAPHICS and ATLAS*GIS for manipulation of data on the resulting maps.

Field Work

During the summer of 1993, field work was conducted in the Coto Brus area. During this trip, two persons, who work with livestock and agriculture, and have worked with Indian *campesinos*, were interviewed. Some other persons were asked about issues concerning the San Vito community and their perspectives of development.

Information was gathered about the Indian villages, access, cultivation, and their current interaction with Ladino communities in the town of San Vito. The village of Brusmalís was visited to talk to the current *Cacique* and other village people (Appendix 7 and 8). This village is located about ten kilometers from San Vito. The paved road

leaving San Vito goes northeast passing by the village of Sabanilla. From this point, an all-weather road leads to Brusmalís. The access is easy by automobile during the summer; for the rainy season, the best way is with a 4-wheel drive truck or on horseback.

Data Processing

Aerial photographs, maps, computer hardware and software, and the field work were processed and analyzed to obtain the results and conclusions.

First, the aerial photographs were located on the topographic sheets to determine the boundaries of the study area. The location of specific points in each photograph was recorded in ATLAS*DRAW to be able to digitize each photograph into the computer. Before digitizing, forest and non-forest areas on the photographs were selected and then differentiated with China pencil to mark their boundaries to ease the digitizing. The smallest unit chosen was of 0.02 km^2. Forest and non-forest areas were registered into the computer as regions with unique IDs. ATLAS*GRAPHICS was used to check consistency on the regions names and IDs. The maps drawn with these regions, lines, and points were imported into ATLAS*GIS to manipulate data and the general look of the maps. The most important information obtained through ATLAS*GIS was the statistics for the deforestation rates of the study area. These statistics were used to accomplish the first objective of this study.

Literature review, deforestation maps, the land-use map, and interviews of the field work were analyzed to get the results and conclusions. The analysis of this information was used to accomplish the other two objectives about the Indian and Ladinos cultures and their agricultural patterns.

CHAPTER IV

RESULTS

Deforestation Rates

Coto Brus Valley

Two maps were created by digitizing the aerial photographs, from which deforestation could be measured. The study area in the Coto Brus Valley has a size of 381.9 km^2. The total forest coverage for the study area in 1960 was 312.3 km^2 (Figure 6). Assuming that the area was essentially forested before any human activity, the deforestation of the area for 1960 was approximately 69.6 km^2 out of 381.9 km^2 of tropical forest. Table 1 shows that the total forest coverage in 1960 was 81.8 percent, and the nonforested area was 18.2 percent.

In 1992, the forest coverage totaled 141.5 km^2, with 240.4 km^2 deforested (Figure 7). This equals 37 percent of the area in forest, and 63 percent nonforested. From 1960 to 1992, the forest coverage decreased by 54.7 percent, an area of 170.8 km^2.

Coto Brus Guaymí Reservation

Calculations of deforestation rates were made based on the boundaries of the Indian reservation as it existed in

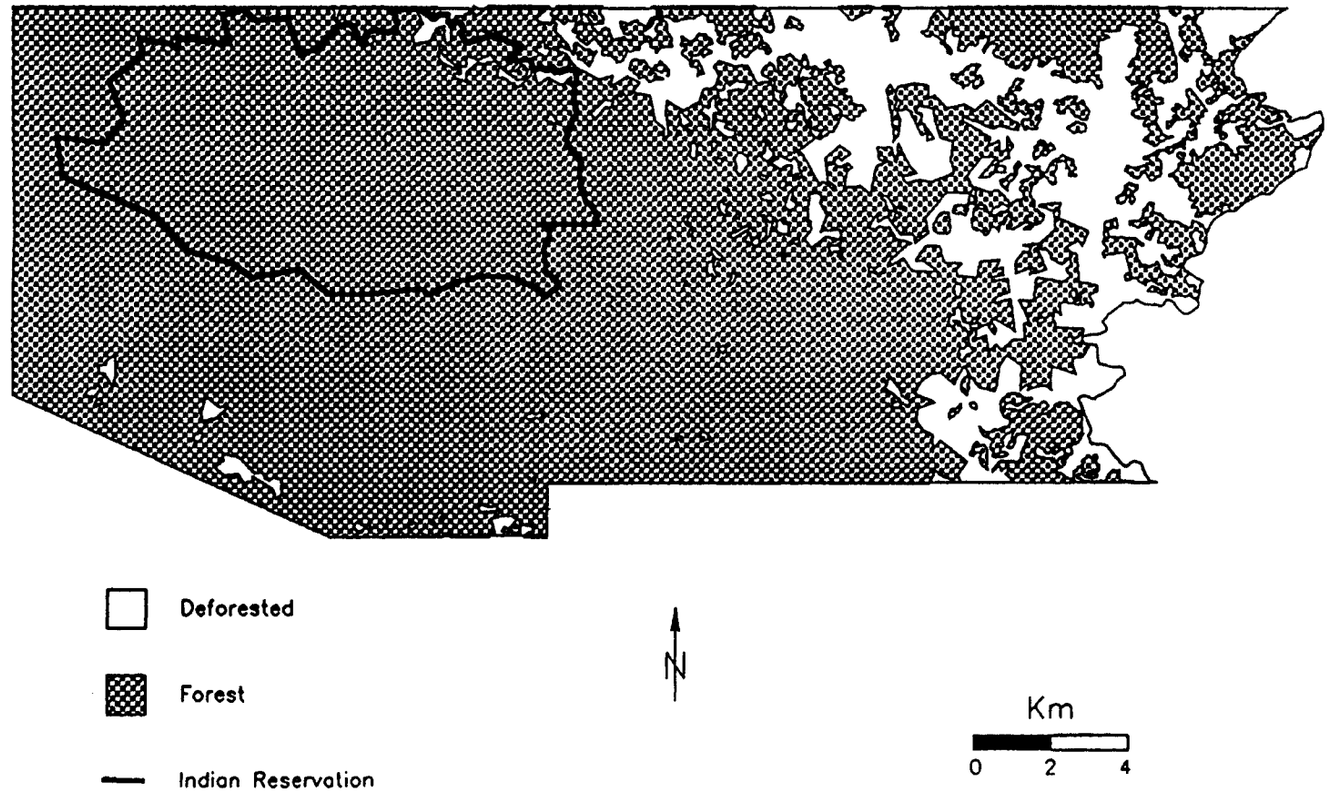

Figure 6. Coto Brus Valley: Forest Coverage in 1960.
Source: Aerial photographs 1960, Instituto Geográfico de Costa Rica

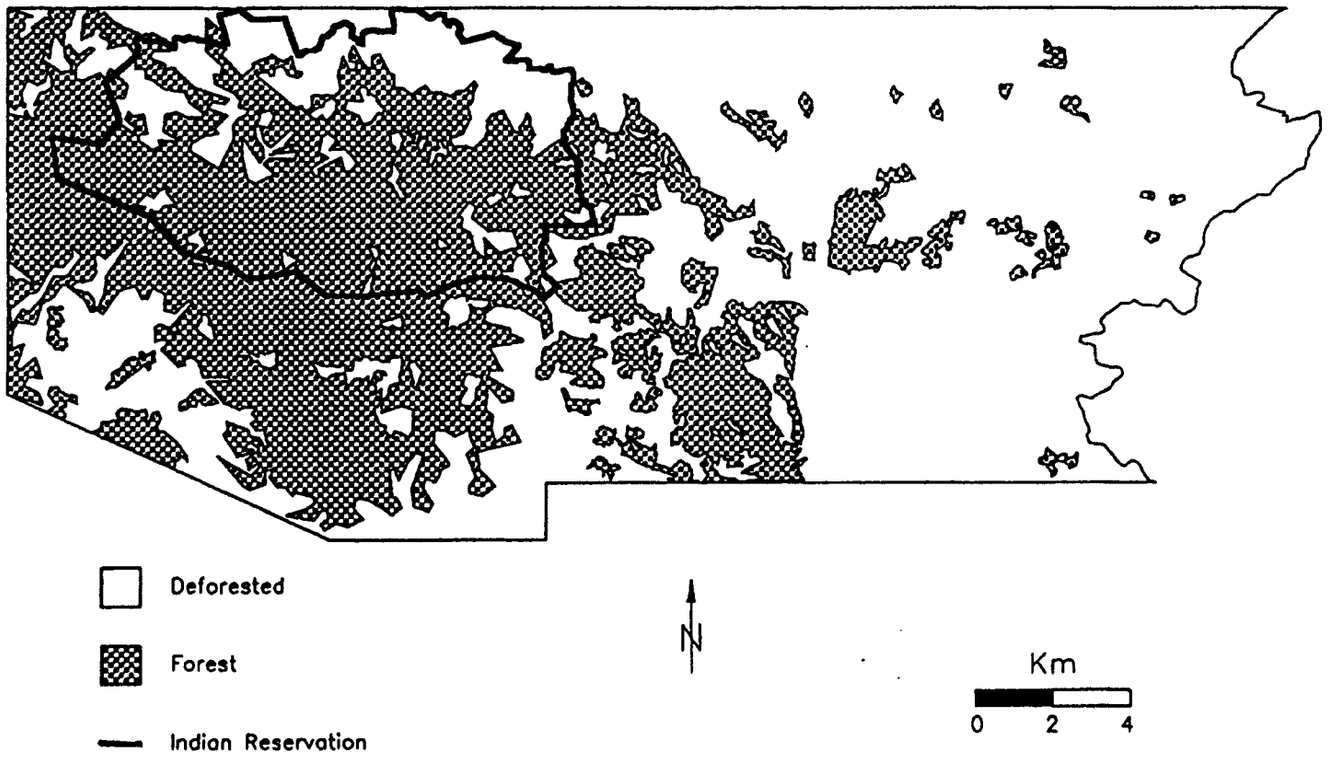

Figure 7. Coto Brus Valley: Forest Coverage in 1992.
Source: Aerial photographs 1992, Instituto Geográfico de Costa Rica

1987. The reservation was approximately 73.2 km². During 1960, the forest coverage was 72.8 km², 99.5 percent of the total area. For 1992, the tropical forest was reduced to 48.3 km², 65.9 percent of the reservation, making the deforested areas within 24.9km², 34 percent of the reservation. Forest coverage within the Indian reservation decreased 33.7 percent between 1960 and 1992.

Table 1. Coto Brus Valley: Total area and deforestation rates for 1960 and 1992 (area in square kilometers)

	Year				
Item	1960	%	1992	%	% Change
Total area (Km2)	381.9	100	381.9	100	
Forest	312.3	81.7	141.5	37.1	54.7
Non - forest	69.6	18.2	240.4	62.9	
Indian Reservation	73.2	100	73.2	100	
Forest	72.8	99.5	48.3	65.9	33.7
Non - forest	0.4	0.5	24.9	34.1	

Source: Aerial Photographs 1960 and 1992, Instituto Geográfico de Costa Rica.

Guaymí Agricultural Patterns

The study done by Jorge Luis Vargas (1988) concerning the tropical environment and indigenous agriculture can help in analyzing patterns identified on the photographs. The 1960 photographs show large areas of clearing located around the main towns and villages (Figure 6). According to Vargas, the indigenes cultivate their crops deep within the forest as an ancient practice. Following this, it can be

assumed that the small areas seen behind the large clearings, following a western direction, were opened by indigenous peasants who were trying to keep a considerable physical distance from the Ladino *campesino* settlements (Laurenchich, 1984) (Figure 6).

This same year's photos show that within the reservation's boundaries shifting cultivation took place on the northeastern side of the boundary of the reservation. This pattern of clearing follows the Limoncito River's course, which represents an important factor for settlement: water availability.

Through the years, Guaymí *campesinos* were pushed further into the forest by the Ladino's spontaneous colonization. Guaymí population was then settled within the boundaries of the potential reservation which was established in 1977. There is a possible reason for the Guaymí population to be kept within these potential boundaries. Here, the slopes in the terrain are very steep. The reservation terrain is identified in the lower mountain zone of the life zones classification. A small part of the area is moist and wet, sometimes enveloped in drizzle, cloud, and fog. These climatic characteristics of the environment could have kept away Ladino colonization.

In the 1992 photographs the northern part of the reservation looks almost completely deforested (Figure 7). This may be due to Guaymís selling their lands to Ladinos despite the fact that this practice is illegal. Areas of shifting cultivation for seasonal crops can be seen for the

rest of the reservation, however, the southern part still has dense forest.

Ladino Agricultural Patterns

The general land use in the Coto Brus Valley shows that cropland dominates over pasture. According to 1956 photographs, both sides of the border between Costa Rica and Panama were mostly converted to agricultural land. On the Costa Rican side, several areas of clearing were identified following the boundary further into the Coto Brus Valley. These clearings surrounded the towns of Agua Buena, Cañas Gordas, Sabalito, and San Vito. The southern and southeastern parts of Agua Buena have large coffee plantations surrounded by pasture and other small crops. Further northeast, the border town of San Antonio also has coffee plantations. More open land can be seen at the northern part of the valley, but the presence of coffee crops is minimal. It seems that pasture was more common in that part of the valley for livestock. Northern Agua Buena does not show a strong agricultural pattern. In examining some patterns and their size, it seems that clearings were open spontaneously based on land availability. San Vito does not have a great deal of agriculture in its surroundings.

By 1960 more land was opened along the road between San Vito and Sabalito. Some coffee plantations were established south and northeast of San Vito. Agriculture seems to be

more intensive near the towns along the border, such as San Miguel.

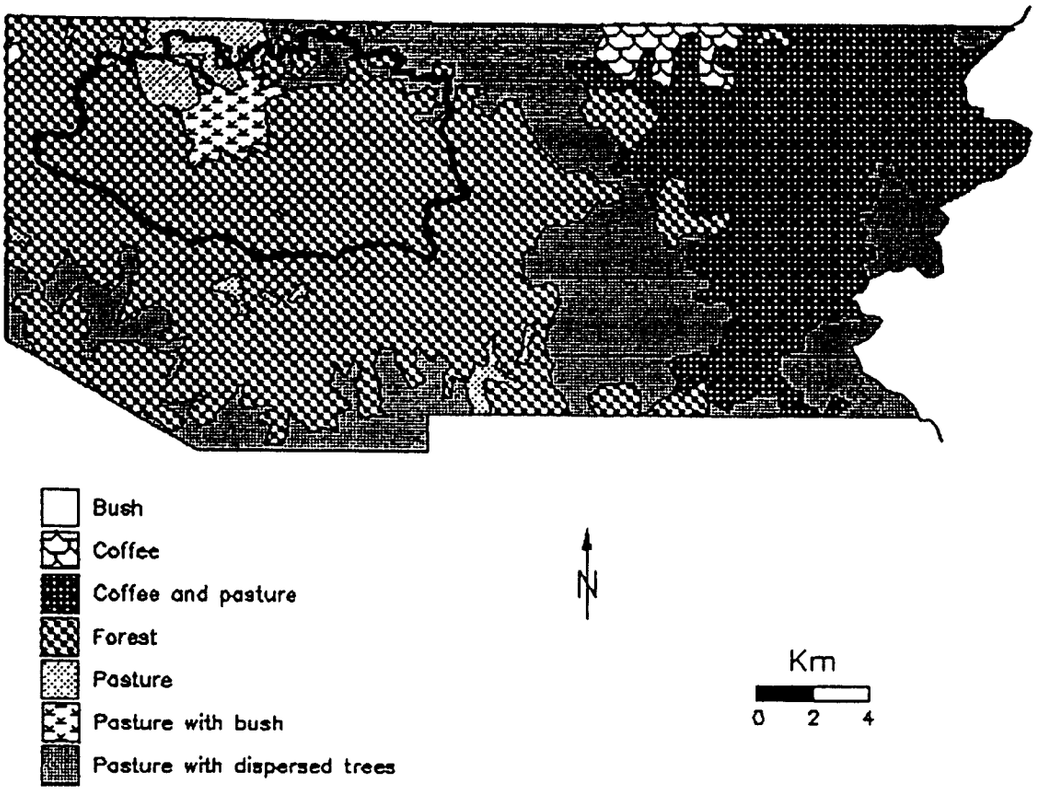

Figure 8. Coto Brus Valley, Land Use 1985
Source: Instituto Geográfico de Costa Rica, 1984

The agricultural pattern described above matches for most of the land-use for 1985 as identified in Figure 8. On this map, the eastern part of the study area is classified as coffee with pasture and is similar to Figure 6, but with much less forest coverage. Two areas with little forest are found along the road surrounded by coffee plantations and pastures with dispersed trees. The northern part of the reservation is identified as pasture with brush, and other diverse pasture with a few forested spots. It seems that by 1985 most of the reservation remained forested with the exception of the northern side.

Comparing these patterns to Figure 7, it can be seen that about half of the study area was converted to pasture with agriculture. In addition, it can also be observed that the southwestern part of the area has been cleared. The reservation forest has also been transformed. Besides the clearing in the northern boundary showed in the 1985 land use map, large areas of clearing can also be identified by 1992, mainly in the central part and western boundary of the reservation.

The Road Factor

The main deforested areas located in the eastern part of the valley and in the northern and eastern boundaries of the reservation, are associated with the roads (Figure 9).

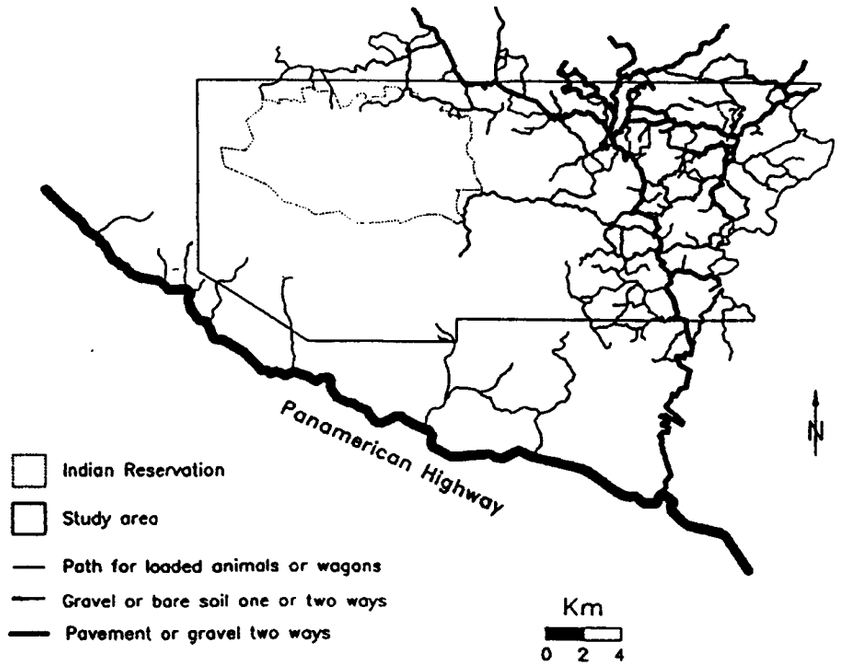

Figure 9. Roads of the Coto Brus Valley., 1992
Source: Topographic Sheets, Instituto Geográfico de Costa Rica

There is a strong spatial concentration of road networks within the eastern portion of the Valley. Between Agua Buena and San Vito there are nine towns within a distance of seven kilometers (4.38 miles). Between San Vito and Sabalito there is a distance of five kilometers (3.13 miles) which includes five towns. One and a half kilometers south of Sabalito, there is another big town, San Bosco. From San Bosco, toward the border in a southeasterly direction, six towns are located. From the San Vito Area, a gravel road leads about seven kilometers westard, toward the reservation. It turns left exactly at the reservation's boundaries, matching the clearings located east of the reservation. No roads are found south of the reservation, the closest village is seven kilometers away from the border.

A gravel road penetrates the northern boundary of the reservation following the Limoncito River's course. This road is broken into three paths that reach the reservation. The areas surrounding these roads are totally deforested.

There are no roads on the eastern side of the reservation which, as the southern part, is still covered with dense forest. One can only conclude that every pattern of deforestation follows the extension of roads into formerly isolated areas (Figure 10).

Interaction between the Ladino and the Indigenous People

Usually, rural communities and Indian communities have many things to share, such as land and public services.

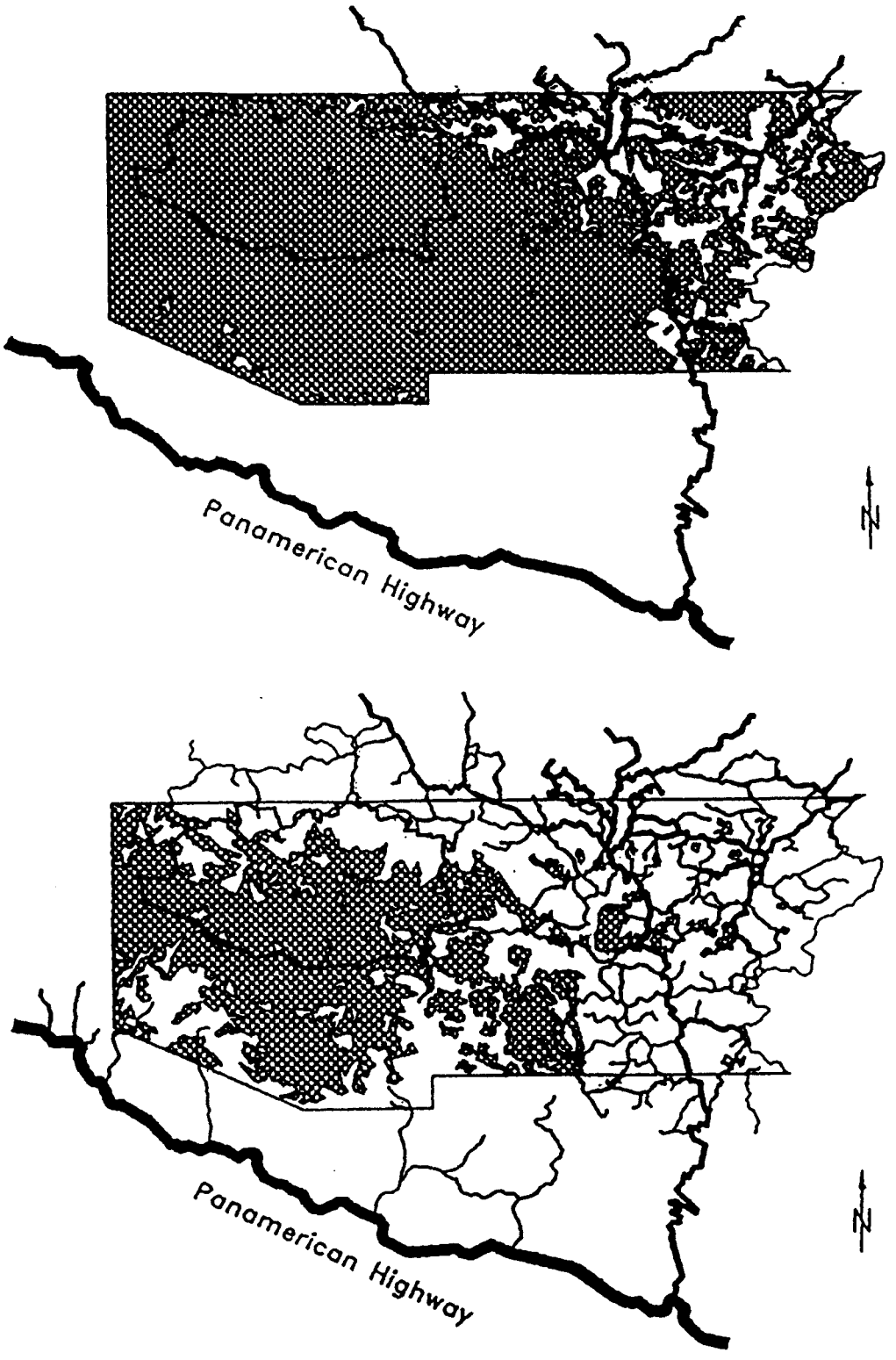

Figure 10. Roads and Deforestation

Source: Topographic sheets, Instituto Geográfico de C. R.

However, the cultural gap perceived in Ladino-Indian relationships is still present.

As a general rule, the Indians in Costa Rica are treated in a discriminatory way. The concept of *Indio* (Indian) is frequently stereotyped as a lazy person, with no education, no possessions, and no job; who is afraid of, and rude to people. With time, this stereotype has been accepted by the same Indians. Other Indians are ashamed of what they are, because of the way other people look at them and treat them. Some other Indians are very proud of being Indians, even thinking that non-Indians are an inferior race. This idea of superiority has been applied to the Guaymís, which can be attributed to Panamanian influences (Panama has a large and strong Indian population).

The most frequent contact between Ladinos and Guaymís in the Coto Brus Valley is the landlord-*peón* (farm hand) relationship. In general, both sides keep a friendly and respectful association.

Most Indians lack the cash to buy food or other basic needs such as shoes, *machetes*, detergent, batteries, building materials, etc. The Guaymís practice subsistance agriculture, planting rice, beans, and maize. They sell these products to buy other products like sugar, flour, coffee, tobacco, and liquor. Within the villages, Guaymí women are very active selling their handmade jewelry, mainly to tourists.

Even though the gap is still wide between these two cultures, Indians are losing the battle against foreign

influences. Some San Vito people believe the Guaymís are very peaceful people who do not care much about money. Others think they possess too much land compared to the areas they cultivate. Preserved forest within the reservation exceeds that found on the land surrounding it. One farmer said that Indians do not clear their land because it is "too divided," meaning that the reservation is divided among a large number of Indians and they have only enough space for subsistance agriculture. Others think they have plenty of room. This is where ignorance reaches Ladinos; the difference lies with the ecological perception from both sides. The Ladino fears the forest: Vegetation should be cleared to protect his family from wild animals and illness. The more forest cleared, the more land available for agriculture and domestic animals. The Indian sees the forest as his refuge and as the source of food and materials, and he has learned to live in harmony with it.

The Guaymí group is preserving its culture at a reasonable level. However, as time passes, and land availability decreases, Indians are adapting to new profitable crops, such as coffee and bananas (Appendix 9 and 10). Other customs are changing such as the material used for building houses and other structures (Appendix 8).

Deforestation vs. Conservation

The San Vito people are becoming aware of the need to respect and preserve the Indian culture and the forest. Local people maintain a good relationship with Indians, but

most of the new immigrants are the ones clearing what forest is left along roads, moving, day by day, closer to the reservation boundaries.

Today, conservation activities are increasing in the valley. One of the leading organizations is the *Organización para Estudios Tropicales* (OET) (Organization for Tropical Studies (OTS)). This international organization manages the *Jardín Botánico Robert and Catherine Wilson* (Wilson Botanical Garden) located in Las Cruces, five kilometers south of San Vito. It is used for preserving and studying plant species found worldwide. Besides this research center, the OTS is starting a conservation project in the largest area of forest left in the eastern part of the valley. The L-shaped area is located west of the botanical garden, surrounded by two other clusters.

The *Asociación para la Naturaleza de Coto Brus* (APENABRUS) (Association for the Nature of Coto Brus) is a local conservation organization in San Vito. Recently, the association finished a project that involved the restoration of the vegetation coverage that protects a river that crosses the town of San Vito. A picnic area was created shaded by fruit and wood trees. Signs next to each tree tell the common and scientific name of the tree; other signs warn against littering and encourage the conservation of natural resources.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMENDATIONS

The patterns of deforestation and colonization, coupled with the analysis of agricultural expansion in the Coto Brus Valley revealed in this study, coincide with the phenomena of migrational movements experienced in Costa Rica for the last 20 years. The direction followed by the deforestation and agricultural patterns of Ladinos and Guaymís matches the explanation given by Bozzoli (1974) in her agricultural frontier concept.

The replacement of the forest with agriculture and pasture in the Coto Brus Valley indicates a deforestation rate of 54.7 percent in a period of 32 years. Sixty-six percent of the Guaymí Indian reservation is currently covered by forest with a deforestation rate of 33.7 percent for the same period.

In the study area, the more deforested lands are the ones located along the border with Panama and along the main roads in the valley. The Indian reservation is almost completely deforested in its northern boundary, and more deforestation is taking place on the eastern boundary. Both boundaries have the road factor in common. The opening of roads in the valley, more than any other cause, is encouraging and increasing the cutting of the forest.

Although the Guaymí group is among the most preserved Indian cultures in the country, its population is adapting to new agricultural and social activities.

The good relationship which exists between Indians and Ladinos has influenced the non-Indians to become aware of nature. However, the conflict between deforestation and conservation will reach a critical point in the near future. Despite this awareness, many people, most of them new immigrants, are clearing what forest is left along roads, moving closer to the reservation boundaries.

The recomendations that have been developed in this study are directed toward public education. Specific sources of deforestation rates, such as the maps created in this study, can be useful for environmental education at local schools in the valley. What better example for the need for conservation than the landscape people have in front of their houses? That should be the key point to address in future research in areas where populations need updated studies. Besides local awareness of rural regions, decisions need to be made in the government.

Today, Costa Rica presents a sad image of forest resources. Nationwide, vast areas of primary forest are succumbing to commercial logging, farming, and cattle ranching.

The greatest idea for the government seemed to be the reforestation programs, programs that many people believe are just tree farming activities. The government, supported by international and local organizations, can "reforest" the

entire Coto Brus Valley, however, this is not the best solution. The controversy lies in the fact that farmers need to cut the trees to survive today, but there will be no resources for tomorrow if deforestation is not stopped now.

Reforestation benefits the economy with jobs and profits from investments, but it does not help to maintain the ecological balance. If we want to preserve the ecology of forests, we must preserve the forests just as they are. For these purposes, we could use biological corridors, or so called "reafforestation." Biological corridors are natural trends or paths along which flora and fauna move. There is an international project to create a biological corridor in Central America to provide a pass for species between the two American continents. This ambitiuos project is called *Proyecto Paseo Pantera* (Path of the Panther). The Amistad International Park in Talamanca, is included in this project, and the Wilson Botanical Garden is part of La Amistad International Park. The amount of forest cover left in the Guaymí Reservation, and the importance of the forest areas surrounding the botanical garden to preserve the environment for the species in the garden, brings up a possible option for conservation in the valley. These areas can be joined to serve as a buffer zone to La Amistad park. These remaining forests would then be better protected if they are identified as part of a biological corridor. Forests would be kept just as they are, and many permanent jobs would be created, encouraging environmental education for the population.

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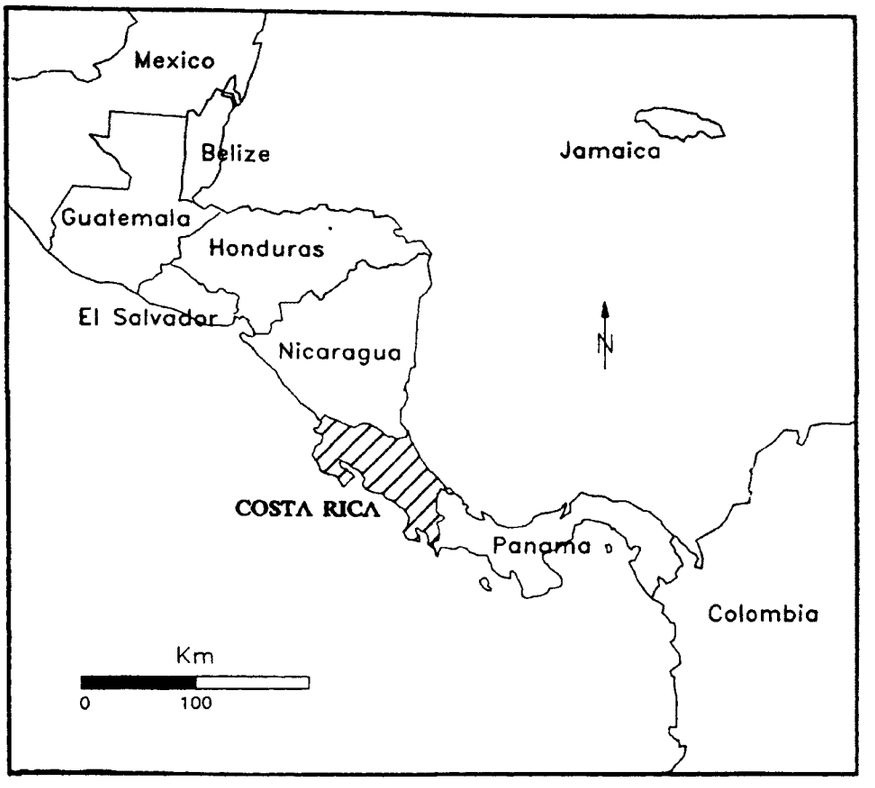
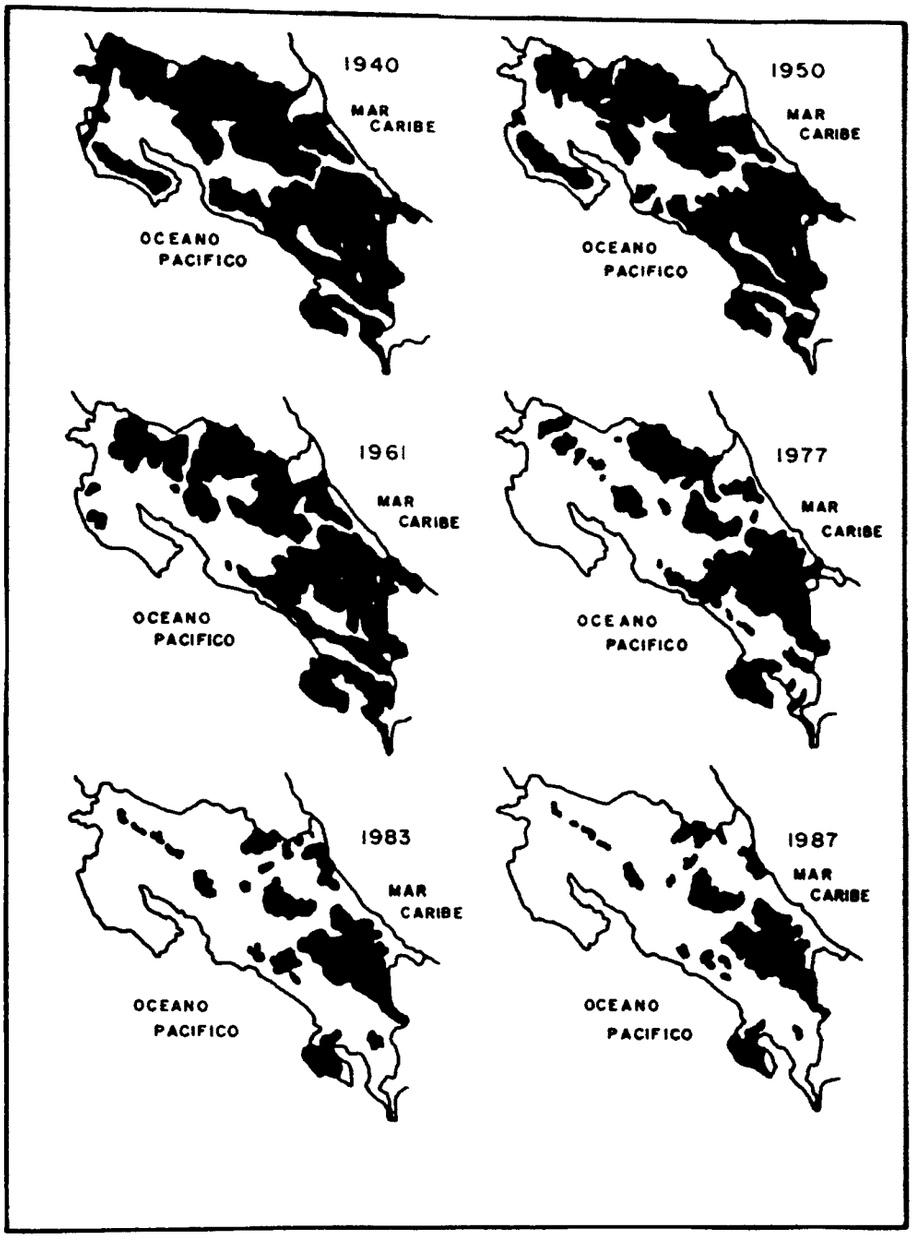
APPENDICES

Appendix 1. Location of Costa Rica.



Source: Central America and the Caribbean, Map Collection, OSU, 1988.

Appendix 2. Dense Forest Coverage (80-90%, 50% coverage) in Costa Rica for the years 1940, 1950, 1961, 1977, 1983, and 1987.



Source: Fundación Neotrópica, 1988.

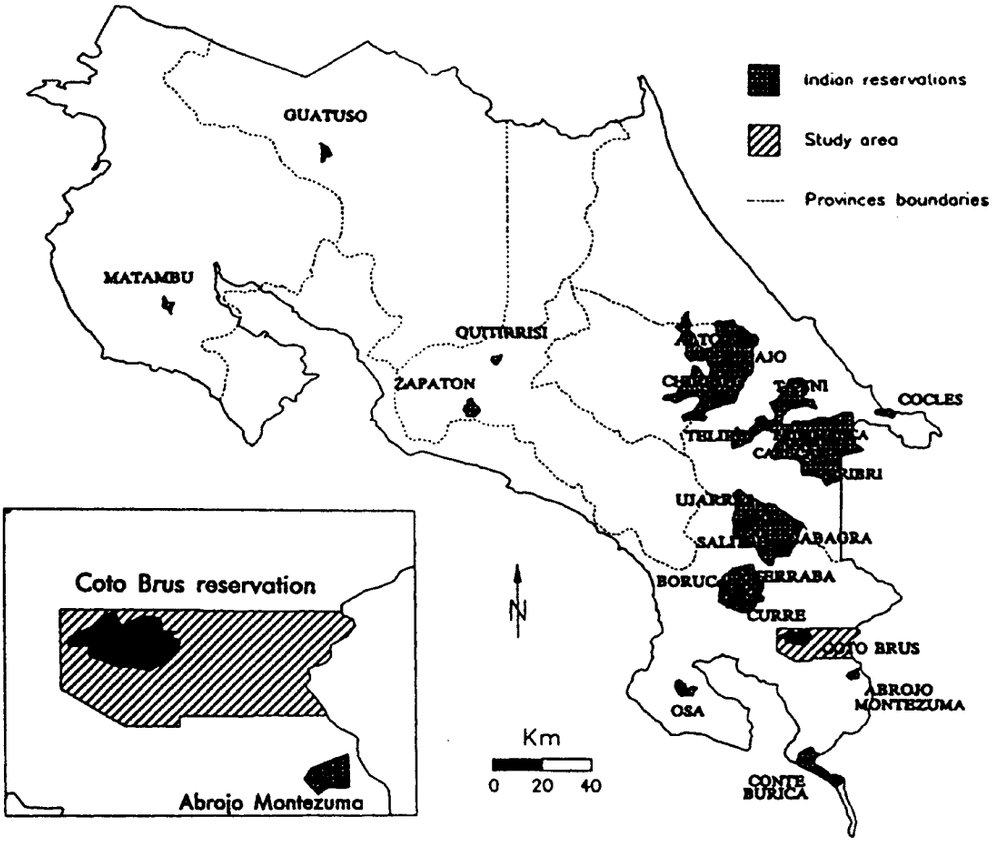
Appendix 3. List of Private Wildlife Refuges, 1988

Organization in charge	Refuge name	Area (Ha)
Organización para Estudios Tropicales (OET)		
	Reserva Biológica La Selva	1430
	Jardín Botánico Robert & Catherine Wilson [1]	127
Centro Científico Tropical		
	Reserva Biológica Monteverde	5000
Centro Agronómico Tropical de Investigación y Enseñanza		
	Reserva Biológica Los Espaveles	200
Unversidad de Costa Rica		
	Reserva Biológica Tres de Junio	750
Familia Miranda		
	Estación Biológica Marenco	422
Asociación Ecológica La Pacífica		
	Hacienda La Pacífica	1332
Total		9261

[1] Called El Jardín Botánico Las Cruces until March 18, 1987.

Source: Fundación Neotrópica, 1988.

Appendix 4. Indigenous Reservations of Costa Rica



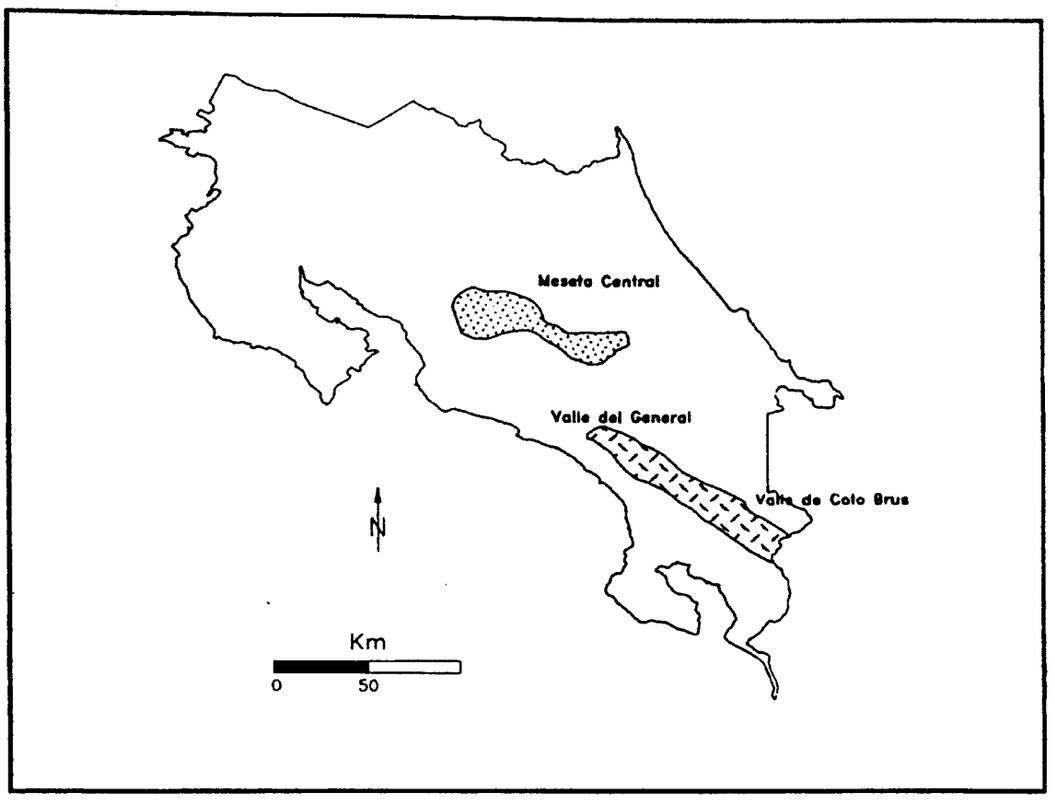
Source: COMAI, 1988.

Appendix 5. Land Tenure and Forested Areas in the Guaymí Indian Reservations

Item	Indian Reservation			
	Conteburica	Coto Brus	Abrojo-Montezuma	Guaymí de Osa
Total Area (Ha)	11910	7500	1400	2713
Land Owned by Indians				
Absolute (Ha)	7746	6675	740	2577
Relative (%)	65	89	53	95
Land Owned by no Indians				
Absolute (Ha.)	4164	825	740	136
Relative (%)	35	11	53	5
Forested Area				
Absolute (Ha.)	8200	5250	544	2373
Relative (%)	69	70	39	87

Source: COMAI, 1992.

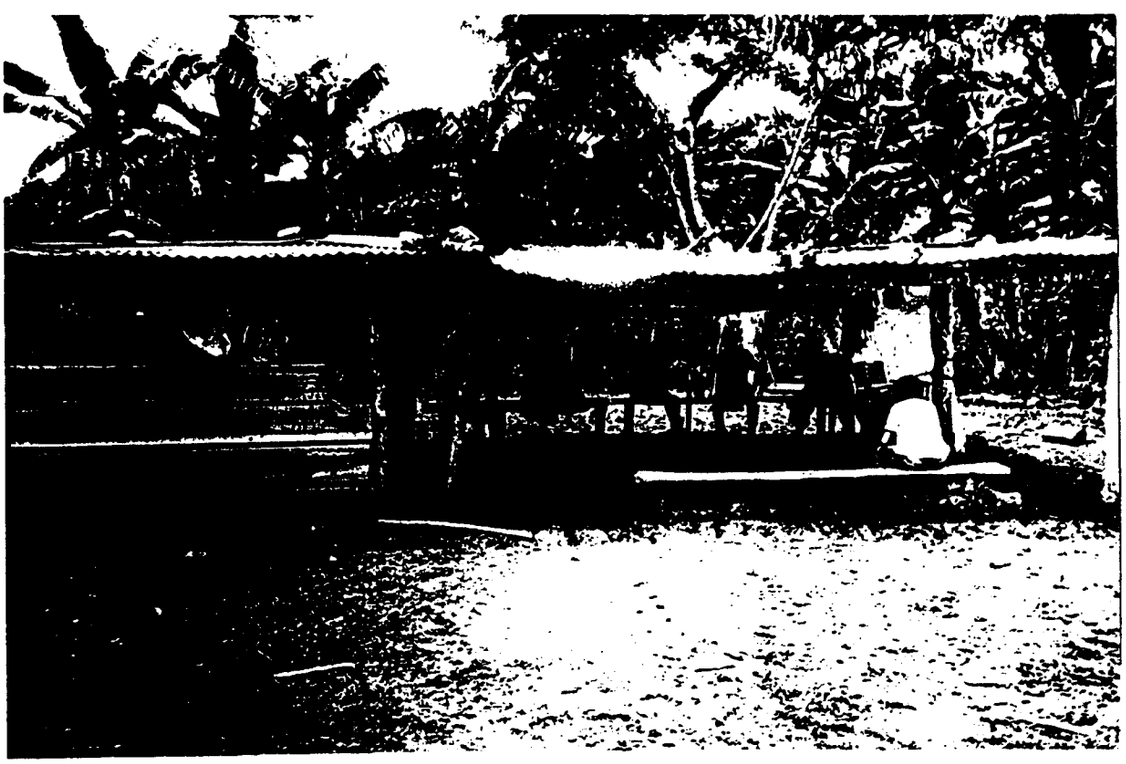
Appendix 6. The General and Coto Brus Valleys.



Source: Hall, 1985.

Appendix 7. Brusmalís' Communal House.

Appendix 8. Current Caciques' House.



Appendix 9. New Profitable Crops Adopted by Guaymís.

Appendix 10. Small Coffee Plants ready to be Replanted

VITA

Jenny Juárez

Candidate for the degree of

Master of Science

Thesis: **A GIS ASSESSMENT OF DEFORESTATION IN THE COTO BRUS VALLEY OF COSTA RICA**

Major Field: Geography

Biographical:

Personal Data: Born in Ciudad Neilly, Costa Rica, April 1, 1969, the daughter of Tomás Juárez Juárez and Ana María Porras Murillo.

Education: Graduated from the Colegio Académico Diurno de Ciudad Neilly, Ciudad Neilly, Puntarenas, Costa Rica, in December 1985; received Bachelor of Science in Tourism, Universidad Internacional de las Américas, San José, Costa Rica in April 1990; completed requirements for the Master of Science degree at Oklahoma State University in July, 1994.

Experience: 1990. SIGMA 4. Rent-a-car and tourist packages agent. 1989-90. Corcovado National Park. Carried out a recreational management program in La Leona sector. 1989. VARIG, Brazilian Airlines. Reservation, luggage, airport arrival and departure assistant.